Critical Mineral: Manganese

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Overview

Manganese (Mn) is a chemical element that is included on the U.S. Geological Survey's 2022 Final List of Critical Minerals. Pure Mn is a hard, brittle, and silvery gray metal that oxidizes to a sooty black color. Mn is primarily combined with iron (Fe) to make stronger steel alloys. Other industrial uses include oxidizing agents, rubber additives, ceramics, and agriculture. Mn is also an essential nutrient for humans, although like all elements, it can be toxic in very high concentrations.

Figure 1. A receiver kit shown for a SAR80 assault rifle. The receiver and barrel are made of 4140 steel, an alloy containing 0.75 to 1 % Mn, along with carbon (C), chromium (Cr), and molybdenum (Mo). The alloying metals give the Fe improved impact resistance and machinability. Photo by Troy Ess, TTE Precision Metalwerks.

Supply

The world's largest Mn reserves are in South Africa at 560 Mt (million metric tonnes). Australia is second with 500 Mt. Brazil (270 Mt), China (270 Mt), and Gabon (61 Mt) round out the top five countries with Mn reserves. The U.S. has no listed Mn reserves. Remaining Mn deposits in the U.S. are considered to be low grade and of small size. Currently, the Defense Logistics Agency reports there are 18,144 t of high-carbon ferromanganese, an intermediate iron (Fe)-Mn alloy, in the U.S. strategic stockpile. In 2024, for just ferromanganese, the U.S. imported 0.31 Mt.

The top three producers of Mn in 2024 were South Africa (7.4 Mt), Gabon (4.6 Mt), and Australia (2.8 Mt). The U.S. has not produced any Mn ore since 1970. Americans are 100% import-reliant for Mn.

Figure 2. An exposure of psilomelane ore (black) in quartzite (tan) at the Sodak Mn Mine, Beaverhead County, Montana. Photo by Adrian Van Rythoven.

Mineralogy

The main Mn ore mineral is pyrolusite, a Mn oxide mineral. Other oxide minerals such as ramsdellite, romanèchite, hollandite, coronadite, and cryptomelane are possible ore minerals. These Mn-oxides can be found intermixed, and with quartz and Fe-oxides as psilomelane or "manganese wad." The Mn carbonate rhodochrosite is also commonly found with arsenic (As), tungsten (W), bismuth

Figure 3. A 7.8-cm-wide specimen of rhodochrosite from the Emma Mine, Silver Bow County, Montana. Photo by James St. John (CC-BY-2.0).

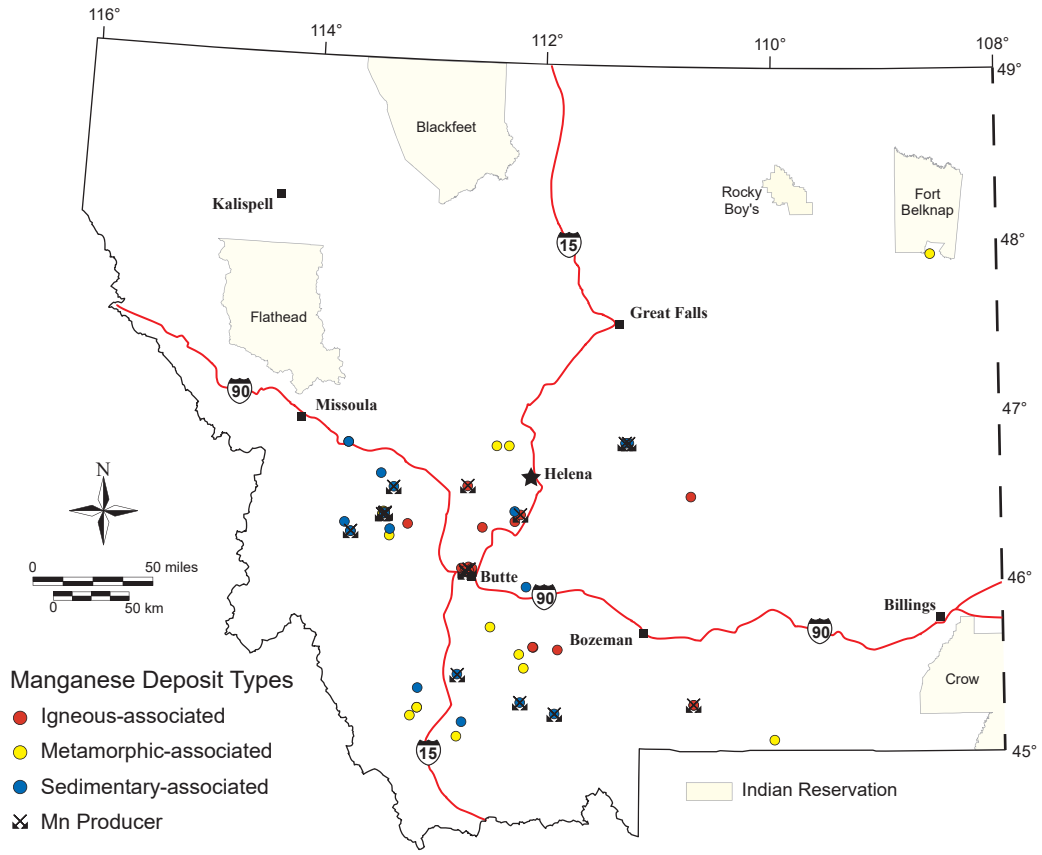

Figure 3. Map of western Montana displaying locations of prospective and known Mn mineralization. Locations of former Mn mines shown.

(Bi), antimony (Sb), gold (Au), lead (Pb), zinc (Zn), tellurium (Te), copper (Cu), and silver (Ag) sulfide deposits. Rhodochrosite readily alters to Mn oxide minerals.

Most metamorphic or igneous rock-associated Mn deposits have rhodochrosite with other metal sulfides. Lower temperature hydrothermal replacement deposits in sedimentary rocks typically have Mn oxide deposits that form by filling in open spaces (cracks or voids). Rarely, psilomelane can be found in placer deposits. The Mn oxide deposits can also contain significant resources of Fe, cobalt (Co), barium (Ba), strontium (Sr), and rare earth elements (REE).

Deposits in Montana

Mn deposits are restricted to western Montana. The sedimentary rock-associated (hosted) deposits are in Granite, Beaverhead, Jefferson, Meagher, Missoula, and Madison Counties. Most of the former Mn mines in Montana are in this group.

Igneous rock-associated Mn deposits are in Silver Bow, Park, Granite, Jefferson, Madison, and Meagher Counties. The remainder of Montana's former Mn mines are in this group. During the first half of the 1900s, Cu-Ag mines in Silver Bow and Granite Counties also produced significant Mn due to wartime demands.

Metamorphic rock-associated Mn deposits are the least common, and typically of lower Mn content. These occur in Beaverhead, Deer Lodge, Granite, Park, Lewis and Clark, Phillips, and Madison Counties.

Outlook in Montana

No Mn exploration, mining, or refining is occurring in Montana. The former mines have been closed for at least 70 years. Prior to that, Montana was one of the most significant Mn-producing states.

Government efforts to document the critical mineral content of mine waste, especially older (legacy) waste, is a recent initiative. The appeal of this initiative is fourfold: (1) secure domestic supply chains for critical minerals, (2) lower mining impacts on the landscape as the material is already fragmented and at the surface, (3) increase employment for legacy mining communities, and (4) rehabilitate legacy mine sites that cause pollution.

About the MBMG

Established in 1919, the Montana Bureau of Mines and Geology (MBMG) continues to fulfill its mandate to collect and publish information on Montana's geology to promote orderly and responsible development of the energy, groundwater, and mineral resources of the State. A non-regulatory state agency, the MBMG provides extensive advisory, technical, and informational services on the State's geologic, mineral, energy, and water resources. The MBMG is increasingly involved in studies of the environmental impacts to land and water caused either by past practices in hard-rock mining or by current activities in agriculture and industry. The Montana Bureau of Mines and Geology is the principal source of Earth science information for the citizens of Montana. More information is available at mbmg.mtech.edu.